INEFFICIENCIES IN THE INTERNATIONAL HOUSING MARKET

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ABSTRACT

Housing markets were found to be inefficient in the past. In this paper, I analyze if this is true for the US, the UK and Canada during the past twenty years. My tests indicate that these markets are inefficient in the sense of traditional financial theory. Based on observed transactions, I find significant and persistent serial correlation. In addition, winner portfolios in one period outperform during the next period. The momentum effect is significant across countries, and persists in a weaker form within countries. However, these inefficiencies cannot be exploited by single investors, who cannot invest in indices, and are faced with lumpy investments subject to idiosyncratic noise. Therefore markets seem efficient in the beat the market sense. Yet, my analysis shows that inefficiencies are economically important on an aggregate level. Postholding period returns indicate that the inefficiencies are caused by market frictions, not speculation. Policymakers can reduce frictions.

DEDICATION

To my loved wife Barbara, who accompanied me to the other side of the world to let me study for this MBA.

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1 INTRODUCTION

1.1 Market Efficiency in the Equity Market

Markets are efficient in the weak-form sense if past returns cannot predict future returns (Fama, 1970). When revisiting his original paper on efficient markets, Fama extends this concept of market efficiency by including predictors other than past returns, such as dividend yields and earnings/price ratio, as well as dividing them into short term predictability (days or weeks) and long term predictability (Fama, 1991). In the stock market the predictable component of short term returns is a small part of their daily variance, but grows to 40% of the variance of 2- to 4-year returns (Fama, 1991, p. 1578).

The efficient market hypothesis has been defended vehemently over the past 30 years. In the early nineties Eugene Fama, who coined its name, has softened his position, conceding for some short term market inefficiencies (Fama, 1991). While this evidence of short term serial correlation is powerful, it is also small and therefore economically not relevant. What is more relevant are long term autocorrelations. Numerous studies have challenged the assumption that equity markets are efficient in the medium to long term. Among the most important evidence is serial correlation, momentum and mean reversion. Jegadeesh and Titman (1993) reject weak-form market efficiency in the US equity market because of momentum, De Bondt and Thaler (1985) because of mean reversion and Rosenberg and Rudd (1982) because of serial correlation. Nowadays, Fama writes that stock prices could become "somewhat irrational" (Hilsenrath, 2004). I pose the same efficiency question for the international housing market, by testing it for serial correlation, momentum and mean reversion.

1.2 Evidence, Causes and Implications of Inefficiencies in the Housing Market

1.2.1 Evidence for Market Inefficiencies

Some argue that the property market is less efficient than the stock market (Evans, 1995, p.27). In fact, the real estate market too has been the object of much analysis on its efficiency. Similarly to the equity market, the analysis has been conducted along two major lines. The first type of analysis postulates a model for the definition of market prices and tests this model for its explanatory power. The parallel in the equity market would be tests of the Capital Asset Pricing Model or the Fama and French (1992) 3-factor model. The second type of analysis focuses on anomalies that should not occur in efficient markets. This line of research focuses mostly on serial correlation as evidence against market efficiency.

Case and Shiller (1989) found that the market for single-family homes in four cities in the US was not efficient due to serial correlation. Englund and Ioannides (1997) estimate a highly significant first-order autocorrelation coefficient at around 0.45 for 15 OECD countries, including the US, Canada and the UK. Also Hamilton and Schwab (1985), Mankiw and Weil (1989), Hosios and Pesando (1991) and Meese and Wallace (1994) report that house price movements are positively correlated over the short run.

Clayton (1996) develops a forward-looking rational expectations house price model and empirically tests its ability to explain short-run fluctuations in single-detached house prices in Vancouver between 1979 and 1991. His model fails to fully capture observed house price dynamics in two real estate booms but tracks real house prices well in less volatile times. This is evidence for periodical deviation from fundamental values in real estate price cycles. He partially attributes these deviations to psychological factors. Englund and Ioannides (1997) construct a model to find that lagged GDP-growth and the real rate of interest exhibit significant predictive power on housing prices in the 15 OECD countries they analyze, along with the autocorrelation reported above. Meen (2002) builds a model based on construction costs. Unfortunately, all these models run into the problem of the joint hypothesis when testing for market efficiency: "[...] Thus, rejection of the rational expectations restrictions may be a result of misspecifying market fundamentals rather than irrational expectations (Clayton, 1997, p. 360)."

Inefficiencies are found across different countries, for different segmentations and for different housing markets. Clayton (1997) reports significant evidence for inefficiencies in the Vancouver condominium apartment market. Englund and Ioannides (1997) find similar inefficiencies across 15 countries, which Meen (2002) confirms for the US and the UK. Clayton (1996) analyzes micro-areas within the Vancouver metropolitan area, as opposed to metropolitan areas, which are the subject of most other studies.

The proponents of efficient real estate market are rare. The most cited is probably Gau (1984). Based on a large sample of Vancouver apartment and commercial transactions over the 1971-1981 period, Gau finds some statistically significant relationships in the price series. However, he also estimates these not to be strong enough to build accurate forecasting models. Locke (1986) utilizes indices of real estate price indices in Great Britain and Australia. He finds statistically significant autocorrelation in Great Britain, but not in Australia. Based on this evidence, Gau (1987) proposed to use market efficiency as a working paradigm for the real estate market, optimistic that subsequent research would have allowed to developing an asset pricing model for the real estate market. This hope was not yet realized.

1.2.2 Causes of Market Inefficiencies

There are two sets of possible explanations for the market inefficiencies observed. They are distinguishable when observing housing prices. The first set results in price overshooting, and the second set in lagged price adjustments. Past literature has found both effects to matter, which is why I test for postholding period returns in section 3.3.

A prominent reason for overreaction is speculation. Levin and Wright (1997) argue that in the short run market imperfections will reduce or eliminate all but the most extreme gains from speculation. Consequently they develop a model where transaction costs do not matter, using owner-occupiers and first-time buyers for whom transaction costs are sunk. They conclude that their analysis "[...] supports the hypothesis that the phenomenon of autocorrelated house prices may be explained by a process of price speculation, not least because the speculative component of house prices also appears to be able to predict turning-points in the real price of houses (Levin and Wright, 1997, p. 1436)." Krainer (2001) offers a second explanation for overshooting: liquidity. He argues that house prices do not vary across states of nature as much as buyers' valuations do. This state varying liquidity causes hot and cold market phases, which could be dubbed as bubbles and their bursts. He goes on arguing for the creation of a rental market for vacant homes, which could dampen this effect, but is unlikely to be met in practice. Other authors recognize housing bubbles too in specific markets. For example Case and Shiller (2003) identify bubble characteristics in certain cities in the US, similar to those experienced previously in 1988. Clayton (1997, p. 359-360) concludes that "[...] housing markets are inefficient and house prices, at times, deviate from fundamental or intrinsic values. In this case, a sharp run-up in house prices is partly due to irrational expectations [...] and signals a future correction, as prices are ultimately anchored by (cointegrated with) market fundamentals."

Lagged price adjustments, on the other hand, are caused by a number of factors observable in practice. Among the most commonly cited market frictions are search costs (DiPasquale and Wheaton, 1994), indivisibility of the assets (Clayton, 1997), heterogeneity (Evans, 1995), infrequent trading (Evans, 1995), transaction costs (Levin and Wright, 1997) and information costs (Capozza, Hendershott and Mack, 2004). All of these lead to market frictions that prevent the market from clearing swiftly. They explain why prices converge to their fundamentals over time instead of instantaneously.

1.2.3 Importance of Market Inefficiencies

The implications of inefficient housing markets are important economically and academically. Inefficiencies challenge current explanatory models. The research results could either be due to a misspecified model or to market inefficiencies. Because of this joint hypothesis, Case and Shiller (1989, p. 135) conclude their research as follows: "There is little hope of proving definitely whether the housing market is not efficient." Therefore, academia has to meet the challenge of coming up with a model for pricing houses that explains real observations.

The economic importance of the housing market is reflected by the amount of wealth held in this market. Englund, Gordon and Quigley (1999) cite the US Department of Commerce (1997) on the fact that housing represents more than half the US private capital stock ($5.87 trillion). Englund and Ioannides (1997) report a similar importance for Europe. Increasing the market efficiency even slightly would therefore have an extremely high impact on the nation's wealth, and enable policy makers to make more substantiated decisions. Case, Quigley and Shiller (2001) find that the housing market appears to be more important than the stock market in influencing consumption in developed countries. Englund, Hwang and Quigley (2002, p. 167) report on the effect of inefficient housing markets on optimal portfolio allocation:

> For short holding periods, the efficient portfolio contains essentially no housing. For longer periods, low-risk portfolios contain 15 to 50 percent housing. These results suggest that there are large potential gains from policies or institutions that would permit households to hedge their lumpy investments in housing.

They find the value of hedges to be surprisingly large, especially to poorer homeowners. On the same lines Case, Shiller and Weiss (1993) argue for the introduction of futures and option markets, as well as index-based over-the-counter derivative markets in real estate. These would allow to overcome the suboptimal portfolio allocation of real estate in private households, and to reduce transaction costs for trading real estate.

For investors the economic importance of inefficiencies in the housing market stretches onto a second dimension. Inefficient markets allow to making profits based on trading rules. Case and Shiller (1989) develop such a rule, but find the noise in individual housing prices to be so great relative to the standard deviation of citywide indices that any forecastability of citywide indices will tend to be swamped. Rayburn, Devaney and Evans (1987) did not find a trading rule able to outperform a buy-and-hold-strategy either. They tested submarkets in Memphis, Tennessee, and found all of them to be weak form efficient for the period 1970-1984. This is evidence of the difficulty of making money out of the insight that housing markets are inefficient. Maybe they are inefficient in the sense of traditional financial theory, but not in the beat-the-market sense, just as Statman (1999) proposes for the equity market.

1.3 Testing for Inefficiencies and their Causes in the International Housing Market

The goal of this paper is to test whether the international housing market is efficient. Based on the evidence exposed in section 1.2.1 I expect it not to be efficient. Since testing models for market efficiency incurs into the joint hypothesis problem, in section 3.1 I start by testing for autocorrelation, based on the methodology used by Case and Shiller (1989). My sample is much larger and internationally diversified than theirs: It includes 161 cities in the US, 20 in Canada and 12 regions in the UK. I find important autocorrelation across all 3 countries I analyze.

To test the economic significance of the inefficiencies found, in section 3.2 I investigate on the return of momentum strategies, replicating the methodology used by Jegadeesh and Titman (1993) for the US equity market. In addition, this methodology also allows me to overcome the problem of common noise that Case and Shiller (1989) solve by randomly splitting their samples into two. Based on the serial correlation found in section 3.1 and on findings from Hong, Lim and Stein (2000), who have shown that momentum strategies are more profitable when information costs are high, I would expect the momentum strategy to be profitable. The results, however, are mixed. The strategy is profitable when allowing to investing in all three countries simultaneously. However, when restricted to investing within one country, the momentum strategy reaps very low excess returns. These are not economically significant. As a result, housing markets seem to be inefficient in the traditional financial sense, but not in the beat-the-market-sense. As a consequence, increased market efficiency may lead to better portfolio allocation and better policy decision, but not necessarily diminish the excess returns yielded by market participants.

The momentum I find internationally is only evidence of inefficient markets if the winner portfolios with a higher return are not exposed to higher risk. My tests in section 3.2.4 imply this not to be the case. In this light, Gau's (1984) efficiency paradigm appears questionable.

To test for the reason of the market inefficiencies, in section 3.3 I investigate on the dynamics of returns in the periods following the holding period of the momentum strategy. I find mean reversion of returns, but not of prices. What I find is strong evidence in favour of market frictions. However, I cannot confirm the research exposed earlier that attributes much of the inefficiencies to (irrational) speculation and changes in liquidity. These findings, as opposed to the momentum results, do not differ considerably between countries.

Section 2 explains the data selection, and section 4 contains concluding remarks.

2 DATA

I analyzed the housing market of three countries: Canada, the United Kingdom (UK) and the United States (US). These countries have indices of housing prices by major metropolitan areas. For the US I used the "Housing Price Indices" (HPI) of the "Office of Federal Housing Enterprise Oversight" (OFHEO).

> [...] OFHEO estimates and publishes quarterly house price indexes for single-family detached properties using data on conventional conforming mortgage transactions obtained from the Federal Home Loan Mortgage Corporation (Freddie Mac) and the Federal National Mortgage Association (Fannie Mae). [...] The HPI are based on a modified version of the weighted-repeat sales (WRS) methodology proposed by Case and Shiller (1989) (Calhoun, 1996, p.1).

This approach limits the extent to which changes in the composition of the sample affect the index (Calhoun, 1996, p.5). It is therefore the most appropriate index to replicate and develop the efficiency tests run by Case and Shiller (1989), since it utilizes the same repeat sales method. Case, Quigley and Shiller (2001) acknowledge that the WRS-Index and the OFHEO index are highly correlated.

For the UK I used the "Halifax House Price Index" (HHPI), published by HBOS, the UK's largest mortgage and savings provider. This index is not based on repeat transactions, but on the price of a "typical house", and is the UK's longest running monthly house price series covering the whole country from January 1983. Prices are disaggregated into their constituent parts using multivariate regression analysis. As a result, this technique allows to tracking the value of a "typical" house over time on a like-for-like basis (HBOS, 2004).

For Canada I used the "New Housing Price Index" (NHPI), published by Statistics Canada and retrieved through "Cansim II" (the Canadian socio-economic information management database). Like the other two indices, it covers detached single unit houses. The

NHPI is a "monthly series that measures changes over time in the contractors' selling prices of new residential houses, where detailed specifications pertaining to each house remain the same between two consecutive periods. [...] Due to the level of geographic detail provided and the sensitivity to changes in supply and demand, the NHPI series are of particular interest to the real estate industry for comparison with changes in values of houses sold in the resale market (Statistics Canada, 2004)." While this index focuses on new houses, as opposed to the previous two, it is therefore still deemed to be a useful proxy for the resale market. In addition, DiPasquale and Wheaton (1994) show how indices for new homes, existing homes and average re-sales move in parallel, although new home indices have a slower long term growth and less cyclical movement.

The datasets range back to 1975 for the US, 1981 for Canada and 1983 for the UK. Since 1983 was the least common denominator for Canada and the UK, I used data tracking back to that date. Of the 331 metropolitan areas contained in the OFHEO HPI, 161 have continuous data tracking back to the first quarter of 1983. The NHPI includes 21 metropolitan areas, of which 20 track back to 1983, and HBOS tracks 12 regions. The time series run up to the second quarter of 2004. The total dataset is therefore composed of 86 time periods and 193 regional and metropolitan areas. Seasonal adjustments are not necessary to build momentum portfolios, because the same seasonal effect affects all prices. Therefore the relative price changes on which the portfolios are formed are not influenced.

All efficiency tests were run for nominal, real and excess returns. To compute the real returns I deflated the nominal returns of the above indices by their country's inflation rate as measured by changes in its CPI. To compute excess returns I deflated the nominal returns by the country's three-month treasury-bill rates. Therefore, all data for the same country are deflated by the same inflation and short term interest rate. Over the total time period I analyzed rolling returns over three different lags: two, four and eight quarters. All returns are quarterly.

The availability of good data is an essential problem with research on housing. For instance, the frequency and valuation method of the indices I use lead to smoothing. This problem is inherent to the asset under observation. Houses are not traded daily on a public exchange, and adjustments need to be made for the idiosyncrasies of each single house. There are hardly any two houses which are the same. Even the weighted repeat sales index used by Case and Shiller (1989) is subject to the influence of time on the same house. Some authors have tackled the problem of unobservable housing value by constructing models. Childs, Ott and Raddiough (2002) developed a model for the optimal valuation of noisy real assets, based on previous research that includes the study by Case and Shiller (1989). The model estimates a true value based on serially correlated observed values. Their argument is based on mean reversion. Alternatively, the noise of single transactions could be eliminated by using appraisals, which have the disadvantage of smoothing and the introduction of a subjective element (Geltner, MacGregor and Schwamm, 2003).

The use of the three indices I chose has important advantages. First, my research uses publicly available data for single-family, detached homes in the countries analyzed. Thus, the object of research is the same for all three countries. Second, these indices are recognized to be leading in their relative countries. Third, to form momentum portfolios, it was important to have a large number of indices to track. Fourth, the values used are observed values, not modelled or appraised values. Modelled values, such as the ones proposed by Childs, Ott and Raddiough (2002), are always subject to assumptions which may not reflect reality. Fifth, the increase in sample size within portfolios reduces the estimation error of single house values. Lastly, they have a long track record.

On the downside, the aggregation of data over metropolitan areas or even regions, as in the UK, has a considerable influence on my conclusion. Since the indices cannot be traded, the implications I find are only theoretical in nature. To have a real impact, investors would have to be able to trade on the indices. Case, Shiller and Weiss (1993) propose the use of derivative instruments to allow for trading on indices such as those I use. In addition, my research could further be improved by including housing income, not only prices. However, to do so would lead to other approximations and research problems.

3 TESTING FOR MARKET EFFICIENCY

3.1 Testing for Serial Correlation

3.1.1 Methodology

"One of the most basic tests of market efficiency is the test for serial correlation of returns. If the return on a typical stock in period *t* is correlated with its return in period *t-1*, then the best (unbiased minimum squared error) prediction for the return in period *t* equals the prior return multiplied by the correlation coefficient. [...] Hence, using knowledge about the previous month's returns, the investor produces a portfolio with superior (mean/variance) performance. This violates the weak-form of market-efficiency (Fama, 1970), [...] (Rosenberg and Rudd, 1982)."

I therefore test the rolling housing index returns for serial correlation. A positive serial correlation would be a strong indicator for market inefficiency. I use the simplest model of return autocorrelation for rolling returns of 2, 4 and 8 quarters (j = 2, 4 and 8), similar to the one used by Case and Shiller (1989, p. 130):

$$\text{Return (t)} = \alpha + \beta * \text{return (t-1)} + \varepsilon \qquad (1)$$

In this model I regress the quarterly return of each of the 193 indices in one period on their average quarterly return in the previous j periods.

3.1.2 Results

The results reported in Table 1 are the means, medians and standard deviations over the coefficients for all 193 geographic areas. Each time series has a β that reflects the autocorrelation of that city. The values for β reported in Table 1 are the mean and the median over these 193 values. The detailed results for each city are reported in appendix 1. I also report the standard deviation of β around this mean value. The t-statistics show the significance of the autocorrelation.

Table 1 Serial Correlation in Real Housing Returns for all Countries

		α	β	Tstat β	R^2
j = 2	Mean	0.0010	**0.6633**	10.3450	0.4884
	Median	0.0010	0.7176	9.1545	0.5085
	Standard Deviation	*0.0011*	*0.2149*	*6.2001*	*0.2539*
j = 4	Mean	0.0006	**0.8473**	18.8199	0.7368
	Median	0.0006	0.8905	16.7486	0.7803
	Standard Deviation	*0.0006*	*0.1420*	*9.1793*	*0.1921*
j = 8	Mean	0.0004	**0.9277**	28.3704	0.8655
	Median	0.0003	0.9594	27.8488	0.9118
	Standard Deviation	*0.0003*	*0.0799*	*12.1269*	*0.1171*

Model: Return (t) = $\alpha + \beta$ * return (t-1) + ε
Method: Ordinary Least Squares
Returns are quarterly real returns of the housing price indices for the US (OFHEO HPI), the UK (HBOS' HHPI) and Canada (Statistics Canada's NHPI), a total of 193 time series. The sample period is Q1 1983 – Q2 2004. The returns are rolling over "j" periods, measured in quarters. Means, medians and standard deviations are calculated over the coefficient values for each of the 193 time series.

These results are strong evidence against market efficiency for detached single family houses.[1] While the average α is very small and statistically insignificant, the average β is considerable and significant. In an efficient market β should be insignificant. The t-statistics are telling that the probability of this is negligible.[2] The standard deviation around the mean β over the 193 cities is small, as is the standard deviation of the β's t-statistic. In fact, only two out of 193 samples showed statistically insignificant autocorrelation. In other words, I can predict next quarter's returns based on the index return over the past year according to the following model:

[1] When accounting for the effects of the overlap, the t-statistics may be weakened.
[2] With this sample size a t-statistic over 2.66 indicates a confidence level of more than 99%.

$$\text{Return (t+1)} = 0.0006 + 0.8437 * \text{return (t)} \quad (2)$$

Table 1 also shows how predictability increases with the measurement period of the rolling returns. The mean β, its t-statistic and the r-squared all increase in j. In other words, most of next quarter's returns are dependent on the return over the previous two years. The high r-squared implies a very close correlation, and the high t-statistic implies that the chances of β being different from zero are nearly 100%.

Next, the doubt may arise whether this model only works for real returns. Case and Shiller (1989) analyze for serial correlation in real and excess returns. They argue that it is in principle possible that the forecastability of returns be really due to the forecastability of real interest rates or the dividend on housing (Case and Shiller, 1989, p. 129).

I find that serial correlation persists using both nominal and excess returns.[3] Table 2 actually shows how the predictability tends to increase for excess returns, with β rising from 0.83 for nominal returns to 0.89 for excess returns. This increase in forecastability using excess returns is likely attributable to the forecastability of real interest rates over the sample period (Case and Shiller, 1989, p. 131). In addition, excess returns lead to a lower volatility of β around its higher mean. The results are very similar between nominal and real returns.

[3] Here I only show the results for j=4. I found similar results for j=2 and 8.

Table 2 Serial Correlation in Housing Returns for all Countries by Type of Return, j = 4

		α	β	Tstat β	R^2
Nominal Returns	Mean	0.0018	**0.8302**	18.9070	0.7171
	Median	0.0012	0.8910	17.4363	0.7937
	Standard Deviation	*0.0017*	*0.1771*	*10.1554*	*0.2289*
Real Returns	Mean	0.0006	**0.8473**	18.8199	0.7368
	Median	0.0006	0.8905	16.7486	0.7803
	Standard Deviation	*0.0006*	*0.1420*	*9.1793*	*0.1921*
Excess Returns	Mean	0.0001	**0.8931**	21.6681	0.8030
	Median	0.0002	0.9272	21.1288	0.8496
	Standard Deviation	*0.0006*	*0.1057*	*8.5181*	*0.1470*

Model: Return (t) = $\alpha + \beta$ * return (t-1) + ε
Method: Ordinary Least Squares
Returns are quarterly nominal, real and excess returns of the housing price indices for the US (OFHEO HPI), the UK (HBOS' HHPI) and Canada (Statistics Canada's NHPI), a total of 193 time series. The sample period is Q1 1983 – Q2 2004. The returns are rolling over 4 quarters (j=4). Means, medians and standard deviations are calculated over the coefficient values for each of the 193 time series.

Table 3 exposes how serial correlation is to be found each of the three countries. Serial correlation is highest in the UK. In Canada α is not statistically different from zero, which hints to it being the least efficient market. It is interesting to note that the results for α and β for the US are very similar to those found by Case and Shiller (1998). However, the t-statistics are considerably higher, and the correlations are moderately higher.

Table 3 Serial Correlation in Real Housing Returns by Country, Real Returns, j = 4

		α	β	Tstat β	R^2
Canada	Mean	0.0001	**0.8808**	18.2005	0.7871
	Median	0.0001	0.9062	18.1488	0.8065
	Standard Deviation	*0.0004*	*0.0618*	*4.3252*	*0.0884*
UK	Mean	0.0011	**0.9224**	21.9036	0.8246
	Median	0.0010	0.9462	23.7499	0.8770
	Standard Deviation	*0.0004*	*0.0825*	*6.0605*	*0.1337*
US	Mean	0.0006	**0.8375**	18.6670	0.7240
	Median	0.0006	0.8830	16.3033	0.7709
	Standard Deviation	*0.0006*	*0.1504*	*9.7765*	*0.2027*

Model: Return (t) = $\alpha + \beta$ * return (t-1) + ε
Method: Ordinary Least Squares
Returns are quarterly real returns of the housing price indices for the US (OFHEO HPI), the UK (HBOS' HHPI) and Canada (Statistics Canada's NHPI), a total of 193 time series. The sample period is Q1 1983 – Q2 2004. The returns are rolling over 4 quarters (j=4). Means, medians and standard deviations are calculated over the coefficient values for each of the 193 time series.

In their paper, Case and Shiller (1989) use a lag of 4 quarters. In tables 1-3 serial correlation is found for a lag of 1 quarter. In Table 4 I analyzed US real returns (quarterly average over the previous 4 quarters, j = 4) for different lags between the independent variable and the depended, lagged variable (L = 1 to 16). What I find is, as expected, that intertemporal dependence decreases as the time lag increases. Alpha becomes statistically significant starting at a 2-year lag, while ß becomes statistically insignificant after 12 quarters. The correlation, as measured by r-squared, decreases continuously as the lag increases. As a result, on average, year-on-year price changes in housing prices tend to be followed by changes in the same direction for at least two additional years. As we have seen in Table 1, this relationship weakens when the measurement period shortens, and vice-versa.

Table 4 Serial Correlation in Real Housing Returns for the US with Different Lags between Dependent and Independent Variable, j = 4

		α	β	Tstat β	R^2
Means	L=1	0.0006	**0.8375**	18.6670	0.7240
	L=2	0.0010	**0.7499**	11.9915	0.5906
	L=4	0.0021	**0.4837**	5.6023	0.2968
	L=8	0.0033	**0.3048**	2.9662	0.1445
	L=12	0.0037	**0.1224**	1.0446	0.0630
	L=16	0.0041	**-0.0477**	-0.5526	

Model: Return (t) = $\alpha + \beta$ * return (t-L) + ε
Method: Ordinary Least Squares
Returns are quarterly real returns of the housing price indices for the US (OFHEO HPI), a total of 161 time series. The sample period is Q1 1983 – Q2 2004. The returns are rolling over 4 quarters (j=4). L is the lag between the dependent and the independent variable, measured in quarters. Means are calculated over the coefficient values for each of the 161 time series.

Part of these results may be due to spurious correlations resulting from the fact that the same noise in individual house sales contaminates both dependent and independent variable (Case and Shiller, 1989, p. 129). This is the reason why Case and Shiller (1989, p. 130) use the same type of model, but randomly split each sample into two equal ones and regress the returns of one on the lagged returns of the other. With this method they still find strong serial correlation, in line with my results. In addition, I find serial correlation independently from the methodology of forming the housing index. Each of the three countries analyzed uses a different methodology, and only OFHEO uses a methodology of repeated house sales. And each of them presents evidence for serial correlation. To address the problem that the same noise contaminates both the dependent and the independent variable, I tested for momentum in the housing market.

In light of the evidence so far, the efficient market hypothesis appears not hold to for the detached, single family houses in Canada, the UK and the US. The next chapter will show how important this effect is from an economic perspective.

3.2 Testing for Momentum

3.2.1 Momentum Portfolios in the Equity Market

If stock prices either over- or under-react to information, then profitable trading strategies that select stocks based on their past returns will exist. Based on this thought, Jegadeesh and Titman (1993) investigate the efficiency of the stock market by examining the profitability of 16 such strategies, based on 4 different measurement periods combined with 4 different holding periods. To increase the power of their tests, they included portfolios with overlapping holding periods. What they find is that trading strategies that buy past winners and sell past losers realize significant abnormal returns over the period from 1965 to 1989. In a subsequent paper, they find that these abnormal returns still hold for the period from 1990 to 1998 (Jegadeesh and Titman, 2001).This method seems to provide strong evidence against the efficient market hypothesis in its weak form. It is therefore interesting to test whether such momentum portfolios can be built on returns of the indices in the real estate market, using the same methodology as Jegadeesh and Titman (1993).

3.2.2 Methodology

To start, for each period I ranked the cities by their returns in ascending order.[4] I did this for three different measurement periods: 2, 4 and 8 quarters ($j = 2, 4$ or 8 quarters). In the subsequent period I formed a portfolio of the 20 best performing cities and one composed of the 20 cities with the lowest returns in the measurement period. I held each of these two portfolios for 2, 4 or 8 quarters ($k = 2, 4$ or 8 quarters), and measured their quarterly return. This combination of measurement period and holding period resulted in 9 different strategies.

Like Jegadeesh and Titman (1993), I also increased the power of my tests by forming portfolios with overlapping holding periods. In any given quarter I would therefore hold a

[4] For the UK, HBOS provides indices for regions, not metropolitan areas

combination of k sub-portfolios, each weighting 1/k of the total portfolio. Jegadeesh and Titman (1993) found that the returns of these rebalanced portfolios were very similar to those of a buy and hold strategy.

For example, using a measurement period of 4 quarters and a holding period of 8 quarters the total portfolio was therefore constructed as follows: At the beginning of each quarter t the cities were ranked in ascending order on the basis of their returns over the past 4 quarters. The cities with the 20 highest returns form the winner portfolio, and those with the 20 lowest returns form the loser portfolio. For that quarter *t* my strategy consisted of buying the winner portfolio and selling the loser portfolio. My total portfolio return would therefore be the difference between the two. I would hold this sub-portfolio for 8 quarters. In the same quarter, however, my strategy not only bought this sub-portfolio, but also sold the sub-portfolio formed 8 quarters earlier. Therefore, in any given quarter, my total portfolio is composed of the sub-portfolios chosen in each of the previous 7 quarters and the one chosen at the beginning of the current quarter.

To model this, I computed the return of the winner sub-portfolio, the loser sub-portfolio and the difference between them for each quarter. My total portfolio return then was the average return of the returns of the sub-portfolios formed during the last k quarters. In any given quarter *t*, the return of the winner-portfolio is the average of the returns in *t* of the cities held in the k portfolios formed during the previous k periods. The same is true for the loser portfolio. The return of my strategy of buying winners and selling losers is then the difference of these two portfolio-returns. Subsequently, I averaged the returns of the 86-k time periods in which I held portfolios.

3.2.3 Results

Table 5 shows how all 9 trading strategies yield a quarterly return of more than 2% and up to 3.8% when the strategy encompasses all three countries analyzed. All strategy-returns are statistically very significant, as evidenced by the high t-statistics. The best trading strategy would be to buy winner-portfolios based on a 4-quarter measurement period, sell loser-portfolios based on the same measurement period and hold this portfolio for 2 quarters. This strategy would yield a compound annualized return of almost 16%.

Table 5 Real Momentum Returns for All Countries, m = 20

		Real Returns			T-Statistics		
		k = 2	k = 4	k = 8	k = 2	k = 4	k = 8
j = 2	buy	0.0233	0.0211	0.0160	14.4023	13.4626	10.5280
	sell	-0.0084	-0.0075	-0.0054	-5.1603	-4.8041	-3.5254
	buy-sell	0.0317	0.0287	0.0213	17.7174	16.8886	14.1685
j = 4	buy	0.0259	0.0228	0.0171	17.2902	15.4813	11.5861
	sell	-0.0118	-0.0096	-0.0070	-7.8579	-6.5198	-4.7086
	buy-sell	0.0377	0.0325	0.0241	21.0493	18.9890	15.3630
j = 8	buy	0.0244	0.0222	0.0164	17.8655	16.0017	12.6507
	sell	-0.0116	-0.0103	-0.0081	-8.4885	-7.4561	-6.2343
	buy-sell	0.0360	0.0325	0.0245	21.2801	19.3882	16.1351

Returns are quarterly returns of portfolios formed on quarterly real returns of the housing price indices for the US (OFHEO HPI), the UK (HBOS' HHPI) and Canada (Statistics Canada's NHPI), a total of 193 time series. The sample period is Q1 1983 – Q2 2004. "m" stands for the number of cities held in each of the winner and the loser portfolio. "j" is the measurement period. "k" stands for the holding period. "Buy" is the average return of the winner-portfolios over the total 86-k testing periods, and reflects the "trading strategy" of buying winners. "Sell" is the average return of the loser-portfolios over the total 86-k testing periods, and reflects the "trading strategy" of selling losers. "Buy-sell" is the difference between the above two returns.

These results provide considerable evidence of market inefficiencies. They are in line with what I found using serial correlation to test market efficiency. In an efficient market it should not be possible to form winning portfolios based on the past performance of the cities contained in them. Only if risk was higher for the winner portfolios than for the loser portfolios would this not be the case. Therefore, in section 3.2.4, I test for risk exposure.

Based on the finding that serial correlation is different when looking at nominal, real and excess returns, I analyzed whether the momentum found is still as strong for nominal and excess returns as it is for real returns. The results are shown in Table 6 for a measurement period of 4 quarters. The results for the other 2 measurement periods are similar (see appendix 2).

Table 6 Nominal, Real and Excess Momentum Returns for All Countries, m = 20, j = 4

		Real Returns			T-Statistics		
		k = 2	k = 4	k = 8	k = 2	k = 4	k = 8
Nominal Returns	buy	0.0335	0.0303	0.0242	20.3546	18.6912	15.4079
	sell	-0.0044	-0.0027	-0.0005	-2.7022	-1.6348	-0.3386
	buy-sell	0.0380	0.0330	0.0248	21.1993	19.0457	15.4758
Real Returns	buy	0.0259	0.0228	0.0171	17.2902	15.4813	11.5861
	sell	-0.0118	-0.0096	-0.0070	-7.8579	-6.5198	-4.7086
	buy-sell	0.0377	0.0325	0.0241	21.0493	18.9890	15.3630
Excess Returns	buy	0.0208	0.0180	0.0127	14.4961	12.8484	8.8644
	sell	-0.0177	-0.0151	-0.0119	-12.3450	-10.8083	-8.2876
	buy-sell	0.0385	0.0331	0.0245	22.2226	19.9981	16.0189

Returns are quarterly returns of portfolios formed on quarterly nominal, real and excess returns of the housing price indices for the US (OFHEO HPI), the UK (HBOS' HHPI) and Canada (Statistics Canada's NHPI), a total of 193 time series. The sample period is Q1 1983 – Q2 2004. "m" is the number of cities held in each of the winner and the loser portfolio. "j" is the measurement period. "k" is the holding period. "Buy" is the average return of the winner-portfolios over the total 86-k testing periods, and reflects the "trading strategy" of buying winners. "Sell" is the average return of the loser-portfolios over the total 86-k testing periods, and reflects the "trading strategy" of selling losers. "Buy-sell" is the difference between the above two returns.

Momentum exists independently from looking at nominal, real or excess returns. For each type of index-return, the strategy offers very similar momentum-returns. This contrasts slightly the results obtained when investigating into serial correlation, which tended to increase with excess returns.

Momentum should also increase with a diminishing number of cities held in the winner and loser portfolios, as my statistically significant findings in Table 7 confirm. This is expected because the average return of the winner portfolio will increase when excluding the cities which performed comparatively worse. I chose the number of cities to be included in the momentum-portfolio so that I would have about 8-10 portfolios in total where possible.

Table 7 Real Momentum Returns for All Countries Sorted by Number of Cities in Portfolios, j = 4

		Real Returns			T-Statistics		
		k = 2	k = 4	k = 8	k = 2	k = 4	k = 8
m = 4	buy	0.0359	0.0291	0.0186	17.1504	15.0442	10.2731
	sell	-0.0195	-0.0152	-0.0102	-9.2943	-7.8511	-5.6667
	buy-sell	0.0554	0.0443	0.0288	20.7494	19.0197	15.0055
m = 10	buy	0.0309	0.0263	0.0182	17.4975	15.5213	10.9584
	sell	-0.0151	-0.0122	-0.0086	-8.5621	-7.1592	-5.1470
	buy-sell	0.0461	0.0385	0.0268	20.8384	18.8492	14.9341
m = 20	buy	0.0259	0.0228	0.0171	17.2902	15.4813	11.5861
	sell	-0.0118	-0.0096	-0.0070	-7.8579	-6.5198	-4.7086
	buy-sell	0.0377	0.0325	0.0241	21.0493	18.9890	15.3630

Returns are quarterly returns of portfolios formed on quarterly real returns of the housing price indices for the US (OFHEO HPI), the UK (HBOS' HHPI) and Canada (Statistics Canada's NHPI), a total of 193 time series. The sample period is Q1 1983 – Q2 2004. "m" is the number of cities held in each of the winner and the loser portfolio. "j" is the measurement period. "k" is the holding period. "Buy" is the average return of the winner-portfolios over the total 86-k testing periods, and reflects the "trading strategy" of buying winners. "Sell" is the average return of the loser-portfolios over the total 86-k testing periods, and reflects the "trading strategy" of selling losers. "Buy-sell" is the difference between the above two returns.

So far my tests have shown considerable momentum irrespectively of changes in inflation or in interest rates, or of the number of cities in the winner and loser portfolios. What I found to affect results, however, is the country. Momentum decreases considerably when limiting the possibility to choose between winner and loser portfolios to one of the three countries, as Table 8 shows.

Table 8 Real Momentum Returns for Each Country, j = 4

		Real Returns			T-Statistics		
		k = 2	k = 4	k = 8	k = 2	k = 4	k = 8
Canada m = 4	buy	0.0091	0.0073	0.0048	9.3775	7.6225	4.9650
	sell	-0.0101	-0.0084	-0.0060	-10.4353	-8.8272	-6.2374
	buy-sell	0.0192	0.0157	0.0107	20.3661	18.1373	13.6254
UK m = 10	buy	0.0033	0.0032	0.0027	3.3553	3.3751	3.0122
	sell	-0.0018	-0.0019	-0.0019	-1.8886	-2.0428	-2.0812
	buy-sell	0.0051	0.0051	0.0046	7.0381	7.5537	8.6329
US m = 20	buy	0.0038	0.0039	0.0037	5.4501	5.6167	5.4433
	sell	0.0023	0.0023	0.0024	3.2457	3.4224	3.5771
	buy-sell	0.0016	0.0015	0.0013	5.1621	5.7478	5.4291

Returns are quarterly returns of portfolios formed on quarterly real returns of the housing price indices for the US (OFHEO HPI), the UK (HBOS' HHPI) and Canada (Statistics Canada's NHPI), a total of 193 time series. The sample period is Q1 1983 – Q2 2004. "m" is the number of cities held in each of the winner and the loser portfolio. "j" is the measurement period. "k" is the holding period. "Buy" is the average return of the winner-portfolios over the total 86-k testing periods, and reflects the "trading strategy" of buying winners. "Sell" is the average return of the loser-portfolios over the total 86-k testing periods, and reflects the "trading strategy" of selling losers. "Buy-sell" is the difference between the above two returns.

Two developments become apparent when looking at the single countries. First, momentum is lower for each country separately than for all countries together. Both returns and t-statistics are much lower in Table 8 than found previously. Second, momentum differs considerably between the three countries. While the quarterly return of the momentum strategy with j = 4 and k = 2 is 1.92% in Canada, it is only 0.51% in the UK and a very low 0.16% in the US. Whereas all these returns are statistically significant, they are very small and therefore economically insignificant, even if trading costs were extremely low.

First, these results imply that markets are more efficient within a country than across countries. In this last example, investors supposedly cannot take advantage of inefficiencies across markets. This is reflective of the regional and national nature of the real estate market, and does not come as a surprise. A Canadian investor will be more reluctant to invest in the UK than in his domestic market. As a result, arbitraging between countries will be a much weaker force towards efficient markets than across countries.

In addition, these results imply that the US market is more efficient than the UK market, which is more efficient than the Canadian market. The reason for this, however, is not apparent. Differences and shortcomings in the data may be at the root of this problem. First, it is conceivable that a new housing index, such as the Canadian one, delivers higher variances between the top and bottom portfolios. A second possible explanation to these differences is that in the US common underlying factors are more important than regional differences. The real estate market is driven by factors other than real interest rates and autocorrelation, such as GDP-growth (Englund and Ioannides, 1997), which is not captured in this model. The housing market appears to be more regional in Canada than in the US. A third explanation for the differences may be related to the peculiarity of housing as an asset class, often positioned between bonds and stocks. Private homes have both a capital and an income component. This model only captures the developments of the capital component. This may explain the small real returns of housing.[5] It may also explain the differences among countries: The capital component may be less important in the US than in Canada as compared to the income component of a house value. Lastly, different momentum returns may be due to different risks for the top portfolios. Interestingly the mean returns of the UK and the US buy strategies are similar. However, the momentum strategy (buy-lose) is substantially different. In the US, not only the strategy returns are small, also the spread between the top and bottom portfolios is extremely small. The next section analyzes whether such differences in portfolio returns reflect different risks.

[5] The US housing market offered a modest quarterly real return of only 0.38% over the last 20 years. The average bond return was higher.

3.2.4 Testing for Risk Exposure of Momentum Portfolios

To respond to the critique that the higher return of winner portfolios is a compensation for risk (Conrad and Kaul, 1998), Jegadeesh and Titman (2001) analyze whether winners have different factor sensitivities on Fama and French's (1992) 3-factor model. They do not find significant differences in factor loadings across their 10 portfolios formed on momentum (Jegadeesh and Titman, 2001, p. 708).

I chose to analyze the US as representative for all three countries for risk differences among momentum portfolios, since the US offers the largest sample and the most accurate data for Fama and French's 3-factor model. In addition to the winner and the loser portfolios formed previously, I also formed the 6 same size portfolios in between. Each portfolio contains 20 cities. Their average excess return is shown in the first row in Table 9. For each portfolio time series I then analyzed the loading of its excess return (ER(p)) on Fama and French's 3 factors: the excess return of the equity market (ER(m)), the size-factor (small minus big, SMB) and the book-to-market-factor (high minus low, HML). The model is as follows:

$$ER(p) = \alpha + \beta 1 * ER(m) + \beta 2 * SMB + \beta 3 * HML + \varepsilon \tag{3}$$

The results shown in Table 9 give no indication of any risk patterns across the 8 portfolios. The values for α and β_2 are both significant. However, they do not consistently increase with the average portfolio return. It would be interesting to further investigate why the factor loading on SMB is significant. The factor loadings on HML and the excess return of the market are not statistically significant, nor do they show a consistent pattern.

Table 9 Excess Momentum Returns and Risk by Portfolio, $j = 4$, $k = 2$, $m = 20$

	Portfolio 1	Portfolio 2	Portfolio 3	Portfolio 4	Portfolio 5	Portfolio 6	Portfolio 7	Portfolio 8
Mean Excess Return	-0.0030	-0.0020	-0.0019	-0.0016	-0.0013	-0.0014	-0.0026	-0.0015
α	-0.0032	-0.0022	-0.0020	-0.0016	-0.0013	-0.0016	-0.0029	-0.0015
tstat α	*-3.5418*	*-2.4945*	*-2.3463*	*-1.7299*	*-1.3468*	*-1.7314*	*-2.9632*	*-1.4639*
β_1	-0.0035	-0.0028	-0.0079	-0.0125	-0.0108	-0.0058	-0.0025	-0.0091
tstat $\beta 1$	*-0.2817*	*-0.2423*	*-0.6804*	*-0.9797*	*-0.8585*	*-0.4583*	*-0.1950*	*-0.6730*
β_2	0.0494	0.0358	0.0537	0.0614	0.0598	0.0550	0.0512	0.0512
tstat $\beta 2$	*2.7434*	*2.0796*	*3.1534*	*3.2880*	*3.2446*	*2.9659*	*2.7112*	*2.5899*
β_3	0.0284	0.0248	0.0233	0.0306	0.0215	0.0288	0.0311	0.0182
tstat $\beta 3$	*1.8397*	*1.6772*	*1.5910*	*1.9082*	*1.3581*	*1.8082*	*1.9170*	*1.0737*
r-squared	0.1264	0.0878	0.1430	0.1683	0.1424	0.1385	0.1272	0.0952

Model: $ER(p) = \alpha + \beta_1 * ER(m) + \beta_2 * SMB + \beta_3 * HML + \varepsilon$
Method: Ordinary Least Squares
ER(p) is the expected return of each portfolio formed on momentum, ER(m) is the excess return of the equity market, SMB is the size-factor (small minus big) and HML is the book-to-market-factor (high minus low). Returns are quarterly returns of portfolios formed on quarterly real returns of the housing price indices for the US (OFHEO HPI), the UK (HBOS' HHPI) and Canada (Statistics Canada's NHPI), a total of 193 time series. The sample period is Q1 1983 – Q2 2004. "m" stands for the number of cities held in each of the winner and the loser portfolio. "j" stands for the measurement period. "k" stands for the holding period.

Therefore, if risk is defined as in the equity market model used by Fama and French (1992), it appears that the higher excess returns of the winner portfolios come at no additional risk. This is another important indication for market inefficiencies in the US housing market. It may be interesting to analyze whether momentum portfolios have exposure to other risk factors, such as GDP-growth, to see if other definitions of risk confirm these findings.

3.3 Explaining Market Inefficiencies Using Postholding Period Returns

3.3.1 Postholding Period Returns

Besides momentum, other anomalies have been found in the equity market. Among other factors, studies found that equity returns are related to size (Banz, 1981), to value (book-to-market-value, Basu, 1983) or earnings over price ratio (Rosenberg et al, 1985). As opposed to momentum, these anomalies did not hold beyond the sample periods (Jegadeesh and Titman, 2001, p. 700). The explanation for the persistence of momentum returns is likely found in either compensation for risk (Conrad and Kaul, 1989) or behavioural theories. Jegadeesh and Titman (2001) find that, although behavioural theories are the more probable explanation, evidence is far from conclusive:

> In particular, although our evidence of momentum profits in the year following the formation period is extremely robust, evidence of negative postholding period returns tends to depend on the composition of the sample, the sample period, and, in some instances, whether the postholding period returns are risk adjusted. In other words, positive momentum returns are sometimes associated with postholding period reversals and sometimes are not, suggesting that the behavioural models provide at best a partial explanation for the momentum anomaly (Jegadeesh and Titman, 2001, p. 719).

What they refer to with negative postholding period returns is mean reversion. The returns of the winner portfolios in the postholding period are an indication to the underlying reason for momentum. If markets were efficient, the higher return is a compensation for risk, and therefore the higher returns should continue (Conrad and Kaul, 1998). I found markets not to be efficient in this sense, and can confirm this conclusion with the postholding period returns found in the following section. Therefore, the momentum I found can either be the result of overreaction, in which case it should be followed by mean reversion (de Bondt and Thaler, 1985), or lagged adjustments to new information, in which case the new price level reflects the fundamental asset value incorporating new information (Damodaran, 1993). Therefore, I looked at the postholding returns of the momentum portfolios formed to determine the reason for the momentum found in the previous section.

3.3.2 Methodology and Results

To analyze the postholding returns I used the same methodology as for determining winner portfolios and forming momentum portfolios in the previous section. I used a formation period of 4 quarters (j = 4) and a holding period of 4 quarters (k = 4). Subsequently I introduced lags between the formation period and the holding period. As a result I could see whether the momentum found for the period directly following the formation period continued over subsequent periods. I analyzed returns for lags incrementing by 4 quarters. As for the momentum portfolios, I rebalance every quarter so as to always holding four winning portfolios and shorting four losing portfolios. Therefore, the returns are again averages over overlapping time periods of 4 quarters and cities contained in portfolios.

The results shown in Table 10 are for real returns. The portfolios are formed with 20 cities for all countries as well as for the US (m = 20) and 4 cities for the UK and Canada (m = 4). The first return is that of the measurement period and the second return is the one reported in the previous section as momentum return (lag = 0). From there on, the returns are for incrementing 4-quarter-lags.

Winner portfolios tend to outperform loser portfolios for about 3 years after the formation period (a lag of 8 quarters). After 12 lags the return of the "buy-sell" portfolio, that is the return of the momentum strategy, becomes statistically insignificant. In the next period, the loser portfolio starts and continues to outperform for 7 years, before the difference becomes insignificant again. However, the out-performance of the loser portfolios is negligible in absolute terms when compared with the initial out-performance of the winner portfolios, and therefore economically insignificant.

As opposed to the results for the momentum strategies, these results are equally strong for each of the 3 countries I analyzed. Figure 1 evidences how momentum returns revert to zero for each country. As for the whole sample, I could not find that past winners become losers and past losers become winners, as Jegadeesh and Titman (2001) did for the US equity market.

As a consequence of these results momentum returns in the international housing market appear to be stationary, but with a lagged adjustment to new information. House prices, on the other hand, are a random walk. Figure 2 shows how on average the winner portfolio performs over the 11 years following its inception.

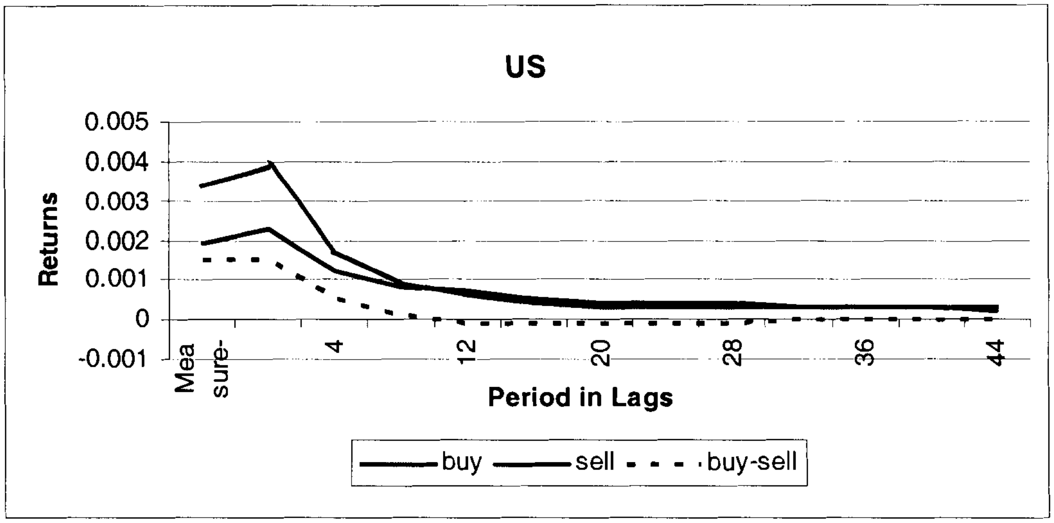
Table 10 Postholding Period Real Returns for All Countries, j = 4, k = 4, m = 20

		Period												
		Measure	Form	4	8	12	16	20	24	28	32	36	40	44
buy	return	0.0273	0.0228	0.0064	0.0018	0.0001	-0.0002	-0.0002	-0.0001	0.0000	0.0001	0.0002	0.0003	0.0004
	t-stat	*17.1858*	*15.4813*	*8.1713*	*3.7438*	*0.312*	*-0.979*	*-1.0738*	*-0.9317*	*0.6537*	*1.7527*	*3.6379*	*4.866*	*5.5271*
sell	return	-0.0148	-0.0096	-0.0025	-0.0009	0.0003	0.0008	0.0009	0.0010	0.0009	0.0007	0.0006	0.0005	0.0004
	t-stat	*-9.339*	*-6.5198*	*-3.1952*	*-1.9383*	*0.9154*	*3.3483*	*4.8311*	*9.1956*	*12.0817*	*12.2976*	*11.9114*	*8.5173*	*6.1444*
buy-sell	return	**0.0421**	**0.0325**	0.0089	0.0028	**-0.0002**	-0.0011	-0.0011	-0.0011	-0.0008	-0.0006	-0.0004	-0.0002	**0.0000**
	t-stat	***19.7516***	***18.989***	*11.7559*	*6.0057*	***-0.7344***	*-5.783*	*-8.1658*	*-10.4997*	*-8.6429*	*-6.6758*	*-5.0176*	*-2.7572*	***-0.591***

Returns are quarterly returns of portfolios formed on quarterly real returns of the housing price indices for the US (OFHEO HPI), the UK (HBOS' HHPI) and Canada (Statistics Canada's NHPI), a total of 193 time series. The sample period is Q1 1983 – Q2 2004. "m" stands for the number of cities held in each of the winner and the loser portfolio. "j" stands for the measurement period. "k" stands for the holding period. "Buy" is the average return of the winner-portfolios over the total 86-k testing periods, and reflects the "trading strategy" of buying winners. "Sell" is the average return of the loser-portfolios over the total 86-k testing periods, and reflects the "trading strategy" of selling losers. "Buy-sell" is the difference between the above two returns. The first period is used to measure performance, in the second period the momentum portfolios are formed (this is the holding period in the momentum study in the previous section), and the subsequent periods are measured in lags between measuring and holding the portfolio.

Figure 1 Postholding Period Real Returns for Each Country Separately, j = 4, k = 4, m = 20

Returns are quarterly returns of portfolios formed on quarterly real returns of the housing price indices for the US (OFHEO HPI), the UK (HBOS' HHPI) and Canada (Statistics Canada's NHPI), a total of 193 time series. The sample period is Q1 1983 – Q2 2004. "m" is the number of cities held in each of the winner and the loser portfolio. "j" is the measurement period. "k" is the holding period. "Buy" is the average return of the winner-portfolios over the total 86-k testing periods, and reflects the "trading strategy" of buying winners. "Sell" is the average return of the loser-portfolios over the total 86-k testing periods, and reflects the "trading strategy" of selling losers. "Buy-sell" is the difference between the above two returns. The first period is used to measure performance, in the second period the momentum portfolios are formed (this is the holding period in the momentum study in the previous section), and the subsequent periods are measured in lags between measuring and holding the portfolio.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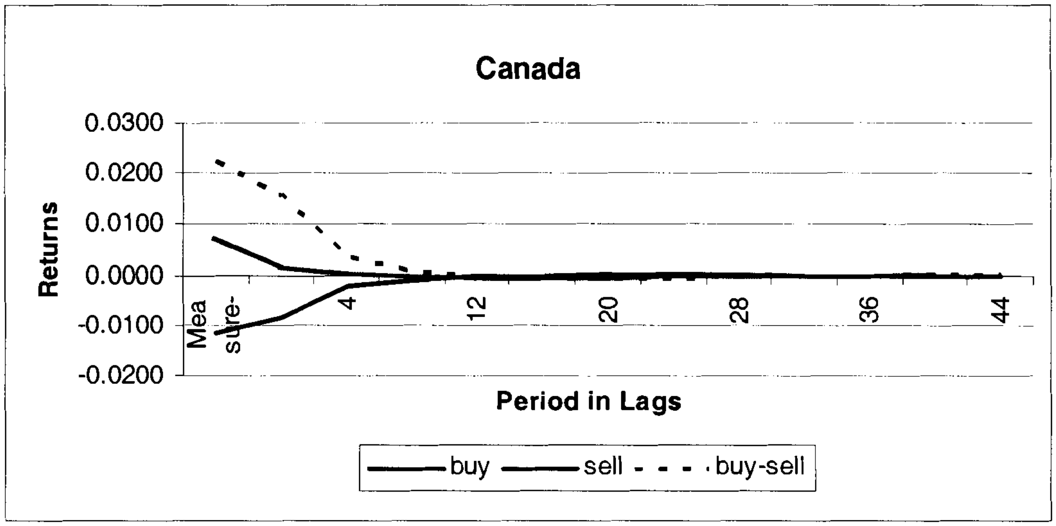
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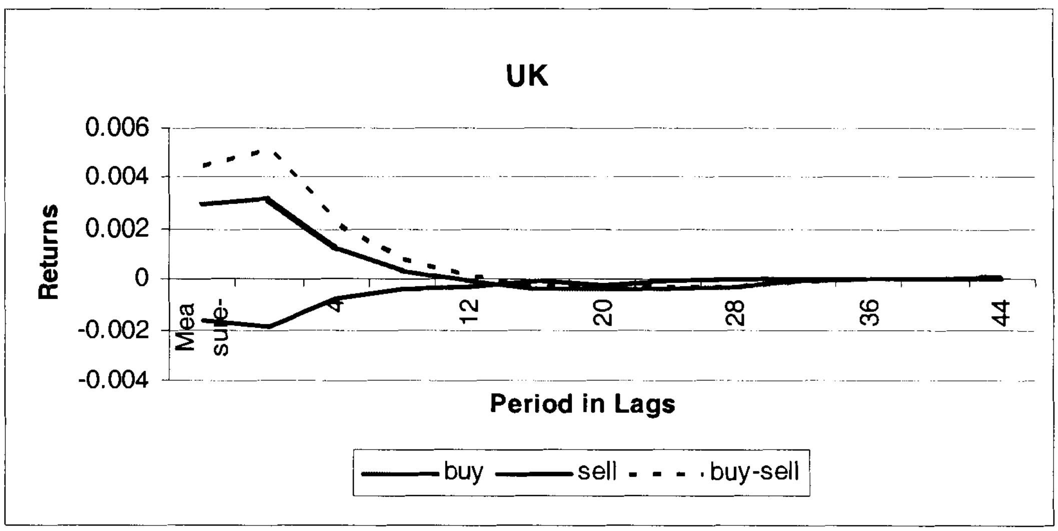
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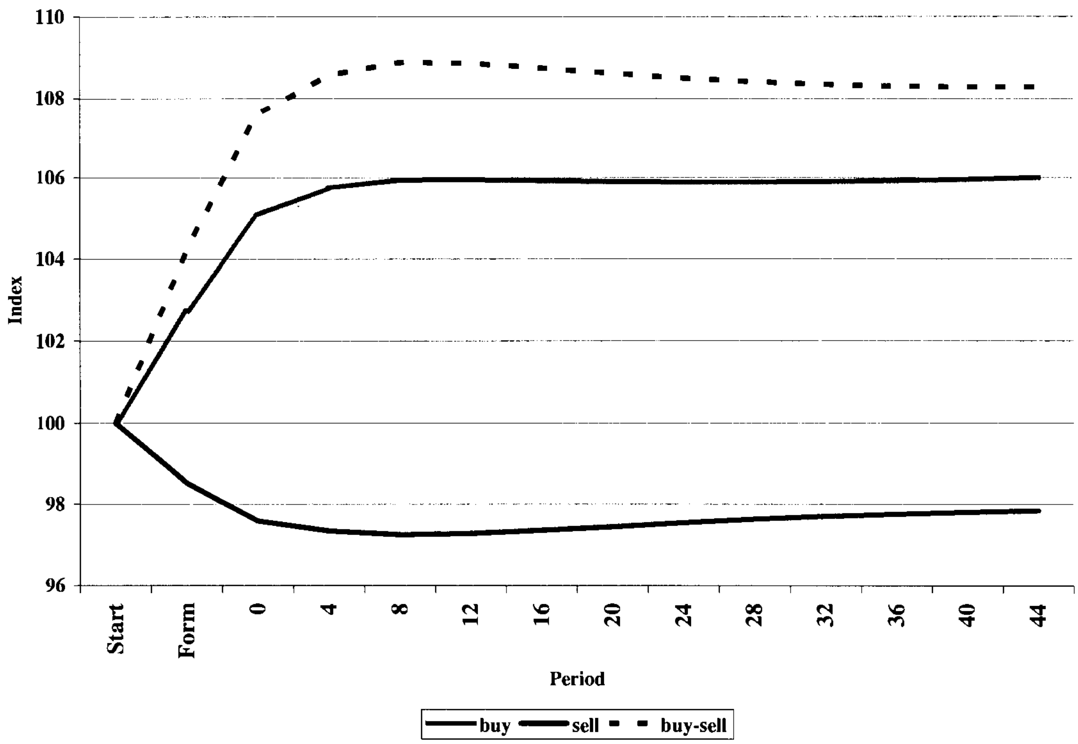
sell
buy-sell

Figure 2 Postholding Period Real Returns for All Countries, j = 4, k = 4, m = 20



Returns are quarterly returns of portfolios formed on quarterly real returns of the housing price indices for the US (OFHEO HPI), the UK (HBOS' HHPI) and Canada (Statistics Canada's NHPI), a total of 193 time series. The sample period is Q1 1983 – Q2 2004. "m" is the number of cities held in each of the winner and the loser portfolio. "j" is the measurement period. "k" is the holding period. "Buy" is the average return of the winner-portfolios over the total 86-k testing periods, and reflects the "trading strategy" of buying winners. "Sell" is the average return of the loser-portfolios over the total 86-k testing periods, and reflects the "trading strategy" of selling losers. "Buy-sell" is the difference between the above two returns. The first period is used to measure performance, in the second period the momentum portfolios are formed (this is the holding period in the momentum study in the previous section), and the subsequent periods are measured in lags between measuring and holding the portfolio.

This picture is reflective of what Capozza, Hendershott and Mack (2004) find for the US, although I find a smaller price overshooting. Englund and Ioannides (1997), on the other hand, find a stronger oscillatory behaviour for 15 OECD countries. My data are convergent, but with only minimal oscillations. If cumulative returns were mean reverting they would have to gravitate back to fundamentals (De Bondt and Thaler, 1989, p. 190). I find that the single-period returns for the momentum portfolios are mean reverting, not their cumulative returns. Therefore, the reason for market inefficiencies is not overreaction, which would result in strong oscillations, but a lagged adjustment of prices to new information, as Damodaran (1993) identified in the equity market. The market is therefore inefficient in the semi-strong form. Other research confirms these findings for different markets. Fu and Ng (2001), for example, determine that in Hong Kong the quarterly real estate prices assimilate only about half the effect of market news. DiPasquale and Wheaton (1994) question and refute what they call the "traditional stock-flow assumption that the housing market clears quickly". From a theoretical point of view they argue as follows:

> The fact that housing prices are incomplete predictors of new construction, the observation that vacancy rates generate gradual price changes and the observed tendency for positive serial correlation in housing prices all can be explained if prices adjust only gradually over a number of periods in response to shocks (DiPasquale and Wheaton, 1994, p. 6).

4 CONCLUSION

Past literature presents extensive evidence of market inefficiencies in real estate markets. Similar results are found for regional as well as metropolitan and sub-metropolitan levels, as well as across several countries. Some of these tests, however, run into the joint hypothesis. Its dilemma is diminished when testing for serial correlation and momentum. Return predictability is tested directly, without any implied models. I find both momentum and serial correlation. Both are statistically significant for the whole sample as well as for each country separately, although the results differ in their values. In addition, I find mean reversion of single-period returns. While the results are both very significant and robust, they are based on a data set that is subject to limitations. First, the indices are measured quarterly, which results in smoothed movements. Second, they are aggregated over large areas. Therefore, local effects can offset each other. Third, it is not possible to invest in the indices. Noise affecting single houses can be larger than the effect of the total market reflected in the index. This limits arbitrage dynamics to only the largest inefficiencies. On the other hand, these data provided a number of advantages. Among them are the large number of cities covered, their long track record, and the large sample size within each index. In addition, the data are based on real observation, not the result of appraisals. With this in mind, I can draw the following conclusions.

Based on the autocorrelation and momentum found, one could predict short term movements in housing price changes and profit from it. For markets to be efficient, I would thus need a model that explains the out-performance of the winner portfolios over the loser portfolios. For instance, it is conceivable that winner portfolios are riskier than loser portfolios. Testing the returns of my samples against the Fama and French three-factor model, I cannot confirm this hypothesis. Therefore, I must conclude that the housing markets in the three countries analyzed are weak-form inefficient. Differences between countries may imply different "degrees" of inefficiency.

A number of reasons are mentioned to be causing these inefficiencies. Among the most cited are speculation and market frictions. Past literature presents evidence for both. Since they manifest themselves differently, I can test for the return patterns in the postholding period to determine which of the two reasons is more likely. If speculation is at the root of inefficiencies, I would expect to observe mean reversion of cumulative returns, the result of overreaction. Market frictions, on the other hand, would manifest themselves through lagged price adjustments. Not cumulative price changes, but single-period returns would be mean reverting. If markets were efficient, out-performance would persist, because the portfolio would be riskier. I find housing markets in each of the three countries analyzed separately as well as all three combined to manifest similar long term patterns. Prices are not mean-reverting, but returns are, with only insignificant oscillations. In other words, returns are stationary and housing prices are a random walk. These oscillations might be more important if prices were measured more frequently. My observations are evidence for market frictions being considerably more important than speculation. It is to be noted that the indices used are for comparatively large areas. It is conceivable that speculation becomes more important when local factors increase in importance.

These findings led my research to a more central question. What is the economic importance of these inefficiencies? Inefficiencies in the sense of traditional finance do not necessarily imply economic inefficiencies in the beat the market sense. Both types are important, but for different reasons and leading to different consequences. For the whole sample spanning all three countries, the return of the previous two years explains more than 90% of this quarter's returns, and the winning portfolio outperforms the loser-portfolio by as much as 16% annually. On the other hand, the strong momentum does not hold when unable to diversify across the countries. The restrained portfolios showed momentum returns which are smaller, still statistically significant, but economically uninteresting. This result was to be expected for a number of reasons. First, country restrictions better reflect reality. Second, my research does not take into consideration transaction costs. Third, it is not possible to buy housing indices, less so shorting them. Therefore, momentum returns cannot be exploited by single investors to achieve excess returns. While inefficient in the sense of traditional financial theory, housing markets are not necessarily inefficient in the beat-the-market sense.

One further observation that this research allowed was how small the returns in real estate were over the past twenty years. Vancouver even experienced a negative cumulative real return in the sample period. It is not the only city that did. The income-component of this asset class seems to play a prevalent role in investors' asset allocation decisions. This is one limitation of this research project that could be tackled upon further research. More importantly, however, investors are constrained by the indivisibility of their asset. Most investors do not appear to be holding their ideal portfolios when including real estate in their optimization decision. Increasing market efficiency, and with it the liquidity of real estate, would allow for a more optimal portfolio allocation. In the light of the wealth invested in housing, the effect of an increase in efficiency in the housing market would be considerable. Housing indices and derivatives would be an important tool to achieve higher liquidity. They would allow to trading on the inefficiencies I exposed. My results show the potential effect that the reduction of market frictions could have on the aggregate wealth. Policymakers have an important role in this regard.

APPENDICES

Appendix 1: The Detailed Results for Serial Correlation of Each City

Model: Return (t) = $\alpha + \beta$ * return (t-1) + ε
Method: Ordinary Least Squares
Returns are quarterly real returns of the housing price indices for the US (OFHEO HPI), the UK (HBOS' HHPI) and Canada (Statistics Canada's NHPI), a total of 193 time series. The sample period is Q1 1983 – Q2 2004. The returns are rolling over 2 quarters.

Country	City	Alpha	Tstat Alpha	Beta	Tstat Beta	R-squared
Canada	1	-0.0007	-3.5	0.8341	24.7	0.8907
	2	0.0001	0.7	0.9985	32.1	0.9321
	3	0.0001	0.6	0.9765	32.5	0.9336
	4	0.0001	0.3	0.9628	29.1	0.9188
	5	0.0003	0.5	0.9679	33.7	0.9382
	6	0.0001	0.5	0.9782	36.9	0.9478
	7	0.0000	0.1	0.9704	36.9	0.9479
	8	0.0002	0.6	0.9594	28.8	0.9171
	9	0.0001	0.2	0.9679	33.2	0.9365
	10	-0.0001	-0.6	0.9279	21.7	0.8622
	11	-0.0003	-0.8	0.8837	16.3	0.7800
	12	0.0001	0.3	0.9636	22.3	0.8687
	13	0.0003	1.5	0.9765	29.4	0.9201
	14	0.0000	0.2	0.9268	20.6	0.8504
	15	0.0010	3.3	0.8383	22.2	0.8682
	16	0.0006	1.9	0.8853	26.4	0.9028
	17	0.0000	0.0	0.9506	25.9	0.8998
	18	0.0003	0.5	0.9746	29.9	0.9228
	19	0.0000	0.1	0.9335	18.8	0.8252
	20	0.0000	0.0	0.9027	19.0	0.8286
UK	21	0.0006	1.1	1.0519	37.7	0.9498
	22	0.0007	1.1	1.0151	36.1	0.9456
	23	0.0006	1.1	1.0286	37.4	0.9491
	24	0.0007	0.9	0.9888	34.6	0.9409
	25	0.0008	1.1	0.9818	32.0	0.9318
	26	0.0005	0.6	0.9743	35.3	0.9433
	27	0.0006	0.8	0.9774	35.3	0.9432
	28	0.0004	0.6	0.9789	39.5	0.9541
	29	0.0003	0.5	0.9792	41.3	0.9579
	30	0.0007	1.1	1.0128	30.5	0.9256
	31	0.0004	0.8	1.0044	16.8	0.7910
	32	0.0011	1.4	0.8347	12.8	0.6856
US	33	0.0012	3.1	0.7358	10.4	0.5921
	34	0.0001	0.2	0.9756	41.7	0.9587
	35	0.0000	0.2	0.9588	28.8	0.9171
	36	0.0001	0.4	0.9732	35.3	0.9432
	37	0.0000	0.1	0.9495	26.8	0.9053
	38	-0.0003	-0.4	0.8738	15.3	0.7572
	39	0.0008	2.2	0.9087	23.4	0.8797
	40	0.0001	0.3	0.9600	30.3	0.9243
	41	0.0005	1.1	0.9720	27.4	0.9093
	42	0.0001	0.2	0.8649	14.6	0.7388
	43	-0.0003	-0.4	0.9416	26.0	0.9000
	44	0.0005	1.4	1.0196	30.5	0.9256
	45	0.0002	0.8	0.9991	36.3	0.9460
	46	0.0001	0.5	0.9661	35.9	0.9451
	47	0.0000	0.1	0.9440	26.5	0.9032
	48	0.0007	1.6	0.9497	29.0	0.9179
	49	0.0000	-0.1	0.9783	53.5	0.9745
	50	0.0004	1.2	0.8698	15.5	0.7626
	51	0.0005	1.0	0.8621	15.4	0.7606
	52	-0.0001	-0.2	0.9742	58.0	0.9782
	53	0.0003	0.7	0.9652	32.2	0.9325
	54	0.0006	1.4	0.9273	22.5	0.8708
	55	0.0000	0.0	0.9786	46.3	0.9661
	56	0.0002	0.5	0.9428	24.5	0.8887
	57	0.0006	2.0	0.8558	16.0	0.7725
	58	0.0007	0.6	0.8324	14.8	0.7439
	59	0.0017	2.6	0.7177	10.8	0.6067
	60	0.0001	0.6	0.9376	23.1	0.8772
	61	0.0009	1.8	0.7062	8.6	0.4977
	62	0.0005	0.9	0.8407	13.7	0.7139
	63	0.0004	1.3	0.9421	24.0	0.8844
	64	0.0007	1.7	0.9714	31.5	0.9298
	65	0.0006	2.4	0.8329	14.4	0.7343
	66	0.0010	3.0	0.7386	9.9	0.5655
	67	0.0002	0.5	0.9435	24.9	0.8923
	68	0.0004	1.5	0.8209	13.3	0.7029
	69	0.0008	2.4	0.7913	11.5	0.6388
	70	0.0000	-0.1	0.9317	21.5	0.8607
	71	-0.0001	-0.4	0.9725	37.7	0.9499

Country	City	Alpha	Tstat Alpha	Beta	Tstat Beta	R-squared
US	94	0.0005	1.8	0.8317	13.4	0.7045
	95	0.0001	0.2	0.9829	45.9	0.9656
	96	0.0003	0.7	0.9833	39.7	0.9546
	97	0.0002	0.7	0.9620	41.3	0.9578
	98	0.0004	1.7	0.8540	14.2	0.7276
	99	-0.0002	-0.5	0.8734	15.8	0.7698
	100	0.0002	0.6	0.9541	25.0	0.8928
	101	0.0009	2.1	0.8064	12.1	0.6616
	102	0.0001	0.6	0.9626	31.0	0.9277
	103	0.0003	0.5	0.9613	33.7	0.9382
	104	0.0003	1.1	0.9319	21.2	0.8571
	105	0.0007	2.1	0.8695	17.0	0.7938
	106	0.0006	1.8	0.9795	21.7	0.8629
	107	-0.0001	-0.3	0.9752	53.5	0.9745
	108	0.0002	0.7	0.8443	13.6	0.7125
	109	0.0013	2.5	0.4125	4.0	0.1731
	110	0.0005	1.8	0.8296	16.2	0.7778
	111	0.0000	-0.1	0.8934	17.2	0.7971
	112	-0.0002	-0.4	0.8155	12.1	0.6603
	113	0.0005	1.2	0.9959	48.4	0.9690
	114	0.0009	2.8	0.8081	13.3	0.7036
	115	-0.0001	-0.3	0.9732	56.3	0.9769
	116	-0.0002	-0.4	0.8379	13.2	0.6977
	117	0.0001	0.4	0.8538	14.2	0.7295
	118	0.0010	2.6	0.8315	15.2	0.7545
	119	0.0003	1.2	1.0293	31.4	0.9295
	120	0.0003	0.7	0.8191	12.5	0.6764
	121	0.0005	1.0	0.9674	27.8	0.9118
	122	0.0006	1.7	0.9732	28.3	0.9144
	123	0.0001	0.2	0.9816	45.9	0.9656
	124	0.0011	3.4	0.8037	14.3	0.7322
	125	0.0004	1.6	0.9674	37.4	0.9491
	126	0.0006	1.4	0.9803	38.2	0.9510
	127	0.0002	0.4	0.9858	48.3	0.9689
	128	0.0001	0.2	0.9485	27.0	0.9068
	129	0.0000	0.0	0.9734	61.7	0.9807
	130	0.0001	0.2	0.9795	42.2	0.9596
	131	0.0002	0.6	0.9608	29.0	0.9181
	132	0.0000	0.0	0.9799	57.3	0.9777
	133	0.0000	0.0	0.9791	50.3	0.9712
	134	0.0002	0.7	0.9930	27.0	0.9064
	135	0.0004	0.9	0.9781	41.7	0.9587
	136	-0.0001	-0.2	0.9250	24.1	0.8859
	137	0.0001	0.2	0.9674	32.2	0.9327
	138	0.0010	1.8	0.8465	14.0	0.7230
	139	0.0002	0.8	0.9394	25.1	0.8933
	140	0.0005	1.3	0.9924	44.8	0.9640
	141	0.0002	0.9	0.9769	29.2	0.9190
	142	0.0013	1.9	0.6298	7.6	0.4340
	143	0.0002	0.7	0.9858	41.4	0.9581
	144	0.0002	0.6	0.9744	35.5	0.9437
	145	0.0006	2.0	0.8392	13.9	0.7197
	146	0.0006	1.9	0.9453	34.2	0.9397
	147	0.0002	0.5	0.9885	48.9	0.9695
	148	0.0000	0.1	0.9455	27.0	0.9068
	149	0.0003	0.8	0.9183	19.4	0.8335
	150	0.0008	2.0	0.9705	32.5	0.9339
	151	0.0005	1.4	0.9831	20.8	0.8517
	152	0.0005	0.7	0.8640	15.0	0.7491
	153	0.0003	1.2	0.9381	21.2	0.8567
	154	0.0005	1.5	1.0104	46.6	0.9666
	155	-0.0001	-0.4	0.9202	23.4	0.8795
	156	0.0004	1.6	0.7942	11.9	0.6553
	157	0.0005	1.3	0.9868	41.2	0.9577
	158	0.0008	1.8	0.7782	10.7	0.6043
	159	0.0001	0.5	0.9581	29.6	0.9211
	160	0.0007	1.4	0.8937	18.4	0.8194
	161	0.0005	1.1	0.9788	38.1	0.9509
	162	0.0002	0.5	0.9643	33.0	0.9354
	163	-0.0001	-0.2	0.9409	23.5	0.8806
	164	0.0004	1.1	0.9978	48.1	0.9687
	165	0.0003	0.7	0.9784	42.5	0.9601

Appendix 2: The Complete Results for Momentum Portfolios

			Nominal Returns			Real Returns			Excess Returns		
			k=2	k=4	k=8	k=2	k=4	k=8	k=2	k=4	k=8
Canada, UK, US			Returns			Returns			Returns		
m=4	j=2	buy	0.0388	0.0332	0.0243	0.0309	0.0255	0.0168	0.0248	0.0196	0.0118
		sell	-0.0046	-0.0035	-0.0012	-0.0118	-0.0104	-0.0074	-0.0194	-0.0176	-0.0137
		buy-sell	0.0434	0.0367	0.0255	0.0428	0.0359	0.0242	0.0443	0.0372	0.0255
	j=4	buy	0.0438	0.0368	0.0260	0.0359	0.0291	0.0186	0.0301	0.0237	0.0139
		sell	-0.0120	-0.0082	-0.0037	-0.0195	-0.0152	-0.0102	-0.0261	-0.0215	-0.0158
		buy-sell	0.0558	0.0450	0.0298	0.0554	0.0443	0.0288	0.0563	0.0451	0.0297
	j=8	buy	0.0406	0.0364	0.0271	0.0327	0.0289	0.0197	0.0274	0.0238	0.0153
		sell	-0.0115	-0.0098	-0.0064	-0.0187	-0.0166	-0.0129	-0.0251	-0.0228	-0.0183
		buy-sell	0.0521	0.0463	0.0335	0.0514	0.0455	0.0326	0.0525	0.0465	0.0336
			T-Statistics			T-Statistics			T-Statistics		
	j=2	buy	14.6585	15.3541	13.5953	12.1996	11.8879	9.1891	10.5908	10.3161	6.7798
		sell	-1.7379	-1.6294	-0.6439	-4.6655	-4.8645	-4.0546	-8.2787	-9.3005	-7.8857
		buy-sell	14.6104	15.3383	13.9302	14.0278	14.5437	13.2109	15.1485	16.1885	14.1151
	j=4	buy	19.0163	17.5582	14.4747	17.1504	15.0442	10.2731	15.4020	13.0389	7.7076
		sell	-5.2208	-3.9061	-2.0640	-9.2943	-7.8511	-5.6667	-13.3368	-11.8198	-8.8114
		buy-sell	21.0418	19.2877	15.5313	20.7494	19.0197	15.0055	21.7503	19.9835	15.2627
	j=8	buy	21.0538	19.6532	16.7627	19.1913	17.6156	13.7266	17.3285	15.7124	10.8683
		sell	-5.9840	-5.2898	-3.9811	-10.9758	-10.1482	-8.9899	-15.8705	-15.0489	-13.0295
		buy-sell	22.8259	21.2944	17.8219	22.3526	20.9604	17.6509	23.3117	21.7141	18.0846

			Nominal Returns			Real Returns			Excess Returns		
			k=2	k=4	k=8	k=2	k=4	k=8	k=2	k=4	k=8
Canada, UK, US			Returns			Returns			Returns		
m=10	j=2	buy	0.0351	0.0314	0.0241	0.0274	0.0240	0.0168	0.0218	0.0187	0.0123
		sell	-0.0027	-0.0021	0.0001	-0.0099	-0.0090	-0.0063	-0.0167	-0.0153	-0.0119
		buy-sell	0.0378	0.0335	0.0240	0.0373	0.0329	0.0231	0.0385	0.0340	0.0242
	j=4	buy	0.0386	0.0338	0.0254	0.0309	0.0263	0.0182	0.0256	0.0213	0.0137
		sell	-0.0076	-0.0050	-0.0021	-0.0151	-0.0122	-0.0086	-0.0215	-0.0182	-0.0140
		buy-sell	0.0462	0.0388	0.0275	0.0461	0.0385	0.0268	0.0472	0.0395	0.0277
	j=8	buy	0.0364	0.0331	0.0253	0.0285	0.0254	0.0179	0.0236	0.0207	0.0137
		sell	-0.0074	-0.0061	-0.0035	-0.0147	-0.0131	-0.0101	-0.0205	-0.0186	-0.0149
		buy-sell	0.0438	0.0392	0.0289	0.0432	0.0385	0.0280	0.0441	0.0393	0.0286
			T-Statistics			T-Statistics			T-Statistics		
	j=2	buy	16.9176	16.4153	14.0776	13.8079	13.0642	9.9355	11.8738	11.1197	7.5857
		sell	-1.3129	-1.0927	0.0712	-4.9826	-4.8863	-3.7157	-9.0655	-9.0890	-7.3482
		buy-sell	16.8734	16.4983	14.0407	16.3782	16.1336	13.6097	17.6317	17.5415	14.6239
	j=4	buy	19.9242	18.4162	14.9309	17.4975	15.5213	10.9584	15.5225	13.5777	8.6049
		sell	-3.9340	-2.7442	-1.2380	-8.5621	-7.1592	-5.1470	-13.0279	-11.5816	-8.7758
		buy-sell	20.9576	18.9191	15.1542	20.8384	18.8492	14.9341	21.9134	19.9466	15.7232
	j=8	buy	20.9645	19.2735	16.4105	18.5949	16.6692	13.0659	16.1969	14.4745	10.2148
		sell	-4.2869	-3.5803	-2.2855	-9.5596	-8.5827	-7.4102	-14.1206	-13.0234	-11.1144
		buy-sell	21.8000	20.0949	17.1050	21.6544	19.8640	16.8348	22.7659	20.9030	17.5071

			Nominal Returns			Real Returns			Excess Returns		
			k=2	k=4	k=8	k=2	k=4	k=8	k=2	k=4	k=8
Canada, UK, US			Returns			Returns			Returns		
m=20	j=2	buy	**0.0311**	**0.0287**	0.0231	0.0233	0.0211	0.0160	0.0182	0.0162	0.0115
		sell	-0.0008	-0.0004	0.0012	-0.0084	-0.0075	-0.0054	-0.0146	-0.0132	-0.0104
		buy-sell	**0.0319**	**0.0290**	0.0219	**0.0317**	**0.0287**	**0.0213**	**0.0328**	**0.0294**	**0.0220**
	j=4	buy	0.0335	0.0303	0.0242	0.0259	0.0228	0.0171	0.0208	0.0180	0.0127
		sell	-0.0044	-0.0027	-0.0005	-0.0118	-0.0096	-0.0070	-0.0177	-0.0151	-0.0119
		buy-sell	0.0380	0.0330	**0.0248**	**0.0377**	0.0325	**0.0241**	0.0385	**0.0331**	**0.0245**
	j=8	buy	0.0320	0.0296	0.0236	0.0244	0.0222	0.0164	0.0196	0.0176	0.0123
		sell	-0.0045	-0.0035	-0.0017	-0.0116	-0.0103	-0.0081	-0.0172	-0.0156	-0.0128
		buy-sell	0.0365	0.0331	0.0253	0.0360	0.0325	0.0245	0.0368	0.0332	0.0251
			T-Statistics			T-Statistics			T-Statistics		
	j=2	buy	18.2192	17.3255	14.7802	14.4023	13.4626	10.5280	11.4515	10.8177	7.8119
		sell	-0.4662	-0.2250	0.7934	-5.1603	-4.8041	-3.5254	-9.1614	-8.8080	-7.0666
		buy-sell	17.9642	17.1422	14.4961	17.7174	16.8886	14.1685	**19.0915**	18.2217	15.2503
	j=4	buy	20.3546	18.6912	15.4079	17.2902	15.4813	11.5861	14.4961	12.8484	8.8644
		sell	-2.7022	-1.6348	-0.3386	-7.8579	-6.5198	-4.7086	-12.3450	-10.8083	-8.2876
		buy-sell	21.1993	19.0457	15.4758	**21.0493**	18.9890	15.3630	22.2226	19.9981	16.0189
	j=8	buy	20.9018	19.0102	15.8207	17.8655	16.0017	12.6507	14.9339	13.2876	9.4746
		sell	-2.9040	-2.2599	-1.1125	-8.4885	-7.4561	-6.2343	-13.0580	-11.8369	-9.8251
		buy-sell	21.5866	19.6752	16.3310	21.2801	19.3882	16.1351	22.6596	20.6001	16.9674

			Nominal Returns			Real Returns			Excess Returns		
			k=2	k=4	k=8	k=2	k=4	k=8	k=2	k=4	k=8
Canada			Returns			Returns			Returns		
m=4	j=2	buy	0.0144	0.0123	0.0099	0.0079	0.0060	0.0041	-0.0015	-0.0030	-0.0042
		sell	-0.0024	-0.0009	0.0009	-0.0089	-0.0072	-0.0049	-0.0183	-0.0161	-0.0132
		buy-sell	0.0167	0.0132	0.0090	0.0167	0.0132	0.0090	0.0167	0.0132	0.0090
	j=4	buy	0.0155	0.0135	0.0105	0.0091	0.0073	0.0048	-0.0001	-0.0015	-0.0034
		sell	-0.0037	-0.0022	-0.0003	-0.0101	-0.0084	-0.0060	-0.0193	-0.0172	-0.0141
		buy-sell	0.0192	0.0157	0.0108	0.0192	0.0157	0.0107	0.0192	0.0157	0.0107
	j=8	buy	0.0151	0.0138	0.0108	0.0088	0.0078	0.0054	0.0000	-0.0008	-0.0026
		sell	-0.0032	-0.0023	-0.0009	-0.0094	-0.0084	-0.0064	-0.0183	-0.0169	-0.0144
		buy-sell	0.0182	0.0162	0.0117	0.0182	0.0162	0.0117	0.0182	0.0162	0.0117
			T-Statistics			T-Statistics			T-Statistics		
	j=2	buy	10.5783	9.9349	8.5380	6.7377	5.6406	4.0761	-1.1630	-2.3457	-3.3683
		sell	-1.7404	-0.7315	0.7767	-7.5898	-6.7086	-4.9219	-13.9563	-12.7238	-10.6297
		buy-sell	14.3763	13.4452	10.8855	14.3769	13.4459	10.8859	14.3767	13.4453	10.8851
	j=4	buy	12.9283	11.5227	9.1115	9.3775	7.6225	4.9650	-0.1184	-1.3707	-2.9330
		sell	-3.0876	-1.9149	-0.2272	-10.4353	-8.8272	-6.2374	-17.7024	-15.5240	-12.2608
		buy-sell	20.4176	18.2227	13.6651	20.3661	18.1373	13.6254	20.3663	18.1374	13.6251
	j=8	buy	13.1428	11.9588	9.6101	10.2269	9.0006	6.2508	-0.0487	-0.8123	-2.7462
		sell	-2.7497	-2.0259	-0.8036	-10.9115	-9.6390	-7.4211	-19.9333	-18.1261	-14.9388
		buy-sell	22.5745	20.0109	15.5225	22.5744	20.0106	15.5223	22.5742	20.0105	15.5220

			Nominal Returns			Real Returns			Excess Returns		
			k=2	k=4	k=8	k=2	k=4	k=8	k=2	k=4	k=8
UK				Returns			Returns			Returns	
m=4	j=2	buy	0.0094	0.0090	0.0085	0.0029	0.0027	0.0027	-0.0065	-0.0063	-0.0056
		sell	0.0047	0.0047	0.0045	-0.0018	-0.0016	-0.0014	-0.0112	-0.0106	-0.0096
		buy-sell	0.0046	0.0043	0.0040	0.0046	0.0043	0.0040	0.0046	0.0043	0.0040
	j=4	buy	0.0097	0.0094	0.0085	0.0033	0.0032	0.0027	-0.0060	-0.0056	-0.0054
		sell	0.0046	0.0042	0.0038	-0.0018	-0.0019	-0.0019	-0.0110	-0.0107	-0.0100
		buy-sell	0.0051	0.0051	0.0046	0.0051	0.0051	0.0046	0.0051	0.0051	0.0046
	j=8	buy	0.0097	0.0093	0.0079	0.0035	0.0033	0.0024	-0.0054	-0.0053	-0.0056
		sell	0.0039	0.0036	0.0029	-0.0024	-0.0024	-0.0026	-0.0112	-0.0110	-0.0106
		buy-sell	0.0058	0.0057	0.0050	0.0058	0.0057	0.0050	0.0058	0.0057	0.0050
				T-Statistics			T-Statistics			T-Statistics	
	j=2	buy	7.5556	7.3604	7.2759	2.7439	2.6727	2.8343	-5.2793	-5.1692	-4.8688
		sell	3.8078	3.8140	3.8182	-1.7007	-1.5733	-1.4309	-9.0418	-8.7330	-8.4084
		buy-sell	6.0731	5.9536	7.3444	6.0740	5.9542	7.3444	6.0733	5.9539	7.3441
	j=4	buy	8.0522	7.8817	7.3391	3.3553	3.3751	3.0122	-5.3103	-5.1281	-5.0376
		sell	3.8098	3.5626	3.3242	-1.8886	-2.0428	-2.0812	-9.8494	-9.8468	-9.3497
		buy-sell	7.0378	7.5530	8.6322	7.0381	7.5537	8.6329	7.0380	7.5533	8.6329
	j=8	buy	8.3284	8.0089	7.2226	3.8875	3.7430	2.9197	-5.4067	-5.3738	-5.8913
		sell	3.3311	3.0658	2.6544	-2.6349	-2.7792	-3.0955	-11.2780	-11.2453	-11.1494
		buy-sell	10.1382	10.2363	10.3245	10.1374	10.2354	10.3238	10.1380	10.2361	10.3245

			Nominal Returns			Real Returns			Excess Returns		
			k=2	k=4	k=8	k=2	k=4	k=8	k=2	k=4	k=8
US				Returns			Returns			Returns	
m=4	j=2	buy	0.0117	0.0110	0.0100	0.0043	0.0039	0.0032	-0.0014	-0.0014	-0.0014
		sell	0.0108	0.0105	0.0095	0.0031	0.0031	0.0026	-0.0027	-0.0024	-0.0024
		buy-sell	0.0009	0.0006	0.0005	0.0012	0.0008	0.0007	0.0013	0.0011	0.0010
	j=4	buy	0.0111	0.0105	0.0096	0.0038	0.0034	0.0029	-0.0015	-0.0015	-0.0015
		sell	0.0108	0.0101	0.0092	0.0034	0.0029	0.0025	-0.0022	-0.0024	-0.0024
		buy-sell	0.0003	0.0004	0.0004	0.0004	0.0005	0.0004	0.0008	0.0009	0.0009
	j=8	buy	0.0117	0.0112	0.0100	0.0045	0.0042	0.0033	-0.0004	-0.0004	-0.0008
		sell	0.0098	0.0094	0.0087	0.0025	0.0024	0.0019	-0.0029	-0.0028	-0.0027
		buy-sell	0.0020	0.0018	0.0013	0.0020	0.0018	0.0014	0.0025	0.0023	0.0020
				T-Statistics			T-Statistics			T-Statistics	
	j=2	buy	11.2654	11.9069	12.1587	4.2594	4.2582	4.0738	-1.1434	-1.2352	-1.4558
		sell	10.3589	11.2754	11.5496	3.0828	3.3938	3.2413	-2.2222	-2.1816	-2.4782
		buy-sell	0.8874	0.7133	0.8553	1.0843	0.9301	1.0983	1.1513	1.1154	1.4416
	j=4	buy	11.6133	11.8001	12.5008	4.0881	3.9595	4.0838	-1.2386	-1.3990	-1.5684
		sell	11.2924	11.3481	11.9586	3.6334	3.3961	3.4672	-1.8704	-2.2238	-2.5552
		buy-sell	0.3761	0.6334	0.8595	0.5109	0.7355	0.8645	0.8807	1.2073	1.4988
	j=8	buy	12.5020	13.1213	13.5421	5.4094	5.7543	5.3686	-0.3633	-0.4655	-0.9402
		sell	10.4173	11.0566	11.7497	2.9750	3.3329	3.1483	-2.7046	-2.9137	-3.2928
		buy-sell	2.7209	2.7402	2.5910	2.7243	2.6210	2.6068	2.9291	2.9325	3.0973

			Nominal Returns			Real Returns			Excess Returns		
			k=2	k=4	k=8	k=2	k=4	k=8	k=2	k=4	k=8
US				Returns			Returns			Returns	
m=10	j=2	buy	0.0117	0.0112	0.0104	0.0043	0.0040	0.0036	-0.0012	-0.0011	-0.0010
		sell	0.0097	0.0097	0.0093	0.0022	0.0024	0.0025	-0.0033	-0.0028	-0.0022
		buy-sell	**0.0020**	**0.0015**	**0.0011**	**0.0020**	**0.0016**	**0.0011**	**0.0020**	**0.0017**	**0.0012**
	j=4	buy	0.0113	0.0109	0.0101	0.0039	0.0038	0.0034	-0.0014	-0.0012	-0.0010
		sell	0.0097	0.0094	0.0088	0.0023	0.0023	0.0021	-0.0030	-0.0028	-0.0025
		buy-sell	**0.0016**	**0.0015**	**0.0013**	**0.0016**	**0.0015**	**0.0013**	**0.0017**	**0.0017**	**0.0015**
	j=8	buy	0.0113	0.0110	0.0101	0.0041	0.0040	0.0034	-0.0008	-0.0007	-0.0007
		sell	0.0097	0.0094	0.0088	0.0025	0.0024	0.0020	-0.0027	-0.0025	-0.0024
		buy-sell	**0.0016**	**0.0016**	**0.0014**	**0.0016**	**0.0016**	**0.0014**	**0.0019**	**0.0019**	**0.0017**
				T-Statistics			T-Statistics			T-Statistics	
	j=2	buy	13.8589	13.9158	13.5831	4.8443	4.8915	4.8440	-1.1261	-1.0967	-1.0507
		sell	11.5173	12.0152	12.1866	2.5321	2.9654	3.3697	-2.9888	-2.7091	-2.3703
		buy-sell	**3.2106**	**3.2629**	**2.9771**	**3.2833**	**3.4104**	**3.0884**	**2.9746**	**3.0793**	**2.9937**
	j=4	buy	14.5468	14.7901	14.6949	4.8605	5.1071	5.3368	-1.2837	-1.1889	-1.1782
		sell	12.5136	12.7729	12.7932	2.8701	3.0597	3.2979	-2.8834	-2.9042	-2.9643
		buy-sell	**3.3723**	**3.6788**	**4.2227**	**3.4856**	**3.7503**	**4.1866**	**3.1954**	**3.3815**	**3.7861**
	j=8	buy	15.4656	15.7366	14.9951	6.0270	6.5022	5.9058	-0.8202	-0.7644	-0.8238
		sell	13.2790	13.5100	12.9657	3.6480	3.9543	3.5183	-2.8389	-2.8959	-2.9248
		buy-sell	**3.3841**	**3.7429**	**4.0660**	**3.4364**	**3.7196**	**4.1515**	**3.5943**	**3.8068**	**4.2186**

			Nominal Returns			Real Returns			Excess Returns		
			k=2	k=4	k=8	k=2	k=4	k=8	k=2	k=4	k=8
US				Returns			Returns			Returns	
m=20	j=2	buy	0.0116	0.0112	0.0105	0.0041	0.0040	0.0037	-0.0014	-0.0012	-0.0009
		sell	0.0100	0.0099	0.0094	0.0025	0.0027	0.0027	-0.0029	-0.0024	-0.0019
		buy-sell	**0.0016**	**0.0013**	**0.0010**	**0.0016**	**0.0012**	**0.0010**	**0.0016**	**0.0012**	**0.0010**
	j=4	buy	0.0112	0.0110	0.0103	0.0038	0.0039	0.0037	-0.0014	-0.0011	-0.0008
		sell	0.0097	0.0095	0.0091	0.0023	0.0023	0.0024	-0.0029	-0.0026	-0.0021
		buy-sell	**0.0015**	**0.0015**	**0.0013**	**0.0016**	**0.0015**	**0.0013**	**0.0015**	**0.0015**	**0.0013**
	j=8	buy	0.0111	0.0108	0.0099	0.0039	0.0038	0.0032	-0.0010	-0.0008	-0.0009
		sell	0.0096	0.0093	0.0088	0.0023	0.0023	0.0020	-0.0027	-0.0025	-0.0022
		buy-sell	**0.0015**	**0.0014**	**0.0012**	**0.0015**	**0.0014**	**0.0012**	**0.0017**	**0.0016**	**0.0014**
				T-Statistics			T-Statistics			T-Statistics	
	j=2	buy	16.3447	15.6166	14.2007	5.2208	5.2164	4.9783	-1.3242	-1.1755	-0.9899
		sell	14.0229	13.8140	12.8016	3.1768	3.5857	3.6530	-2.8402	-2.4448	-2.0801
		buy-sell	**3.8471**	**4.1644**	**3.8111**	**3.8016**	**4.1256**	**3.7293**	**3.2751**	**3.4244**	**3.2801**
	j=4	buy	17.2245	16.5621	14.8287	5.4501	5.6167	5.4433	-1.4963	-1.2214	-0.9407
		sell	14.8911	14.3362	13.0295	3.2457	3.4224	3.5771	-3.0932	-2.9028	-2.4541
		buy-sell	**4.7031**	**5.2259**	**5.1046**	**5.1621**	**5.7478**	**5.4291**	**3.9679**	**4.3309**	**4.3331**
	j=8	buy	18.7402	17.4695	15.0005	6.4402	6.3680	5.4087	-1.1645	-1.0041	-1.0304
		sell	16.2205	15.1584	13.2418	3.8817	3.9170	3.4265	-3.1144	-2.9394	-2.6746
		buy-sell	**5.7121**	**5.6846**	**5.2772**	**6.4499**	**6.2299**	**5.5800**	**5.3956**	**5.3620**	**5.1338**

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